

What is claimed is:

1. A sensor for determining the presence of an analyte in a test sample, said sensor comprising:

5 a nanoparticulate membrane comprising nanoparticles of at least one inorganic oxide of an element selected from Group IA, IIA, IIIA, IVA, IB, IIB, IIIB, IVAB, VB, VIB, VIIB or VIIIB of the Periodic Table, and wherein an oxidoreductase and an electrochemical activator are diffusibly dispersed in said nanoparticulate membrane.

10 2. The sensor according to Claim 1, wherein the oxidoreductase is selected from the group consisting of glucose oxidase, hydrogen peroxidase, horseradish peroxidase, xanthine oxidase, cholesterol oxidase, hydrogen hydrogenase, lactate dehydrogenase, glucose dehydrogenase, NADH dehydrogenase, sarcosine oxidase, lactate
15 oxidase, alcohol dehydrogenase, hydroxybutyrate dehydrogenase, glycerol dehydrogenase, sorbitol dehydrogenase, malate dehydrogenase, galactose dehydrogenase, malate oxidase, galactose oxidase, xanthine dehydrogenase, alcohol oxidase, choline
20 oxidase, xanthine oxidase, choline dehydrogenase, pyruvate dehydrogenase, pyruvate oxidase, oxalate oxidase, bilirubin oxidase, glutamate dehydrogenase, glutamate oxidase, amine oxidase, NADPH oxidase, urate oxidase, cytochrome C oxidase, and actechol oxidase.

25 3. The sensor of claim 1, wherein the electrochemical activator is a polymeric redox mediator capable of transferring electrons between the analyte and an electrode present in the sensor.

30 4. The sensor according to Claim 3, wherein the oxidoreductase is covalently linked to the polymeric redox mediator by cross-linkages.

5. The sensor according to Claim 1, wherein the element selected from Group IA, IIA, IIIA, IVA, IB, IIB, IIIB, IVAB, VB, VIB, VIIB or VIIIB of the Periodic Table is selected from the group consisting of aluminium, silicon, magnesium and zinc.
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6. The sensor according to Claim 1, wherein the thickness of the membrane ranges from 250 to 500 μm .
7. The sensor according to Claim 6, wherein the size of the nanoparticles ranges from 10 nm to 1 μm .
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8. The sensor according to Claim 1, wherein the membrane further comprises a polymeric binder.
9. The sensor according to Claim 8, wherein the polymeric binder is a polymer or copolymer comprising monomer units selected from the group consisting of vinyl pyridine, vinyl imidazole, acrylamide, acrylonitrile, and acrylhydrazide and acrylic acid.
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10. The sensor according to Claim 1, further comprising:
- 20
- a chamber for holding the test sample, said chamber being bounded at least between a working area on a working electrode and a working area on a reference electrode,
- 25
- wherein the oxidoreductase and the electrochemical activator is coated on the working area of the working electrode.
11. The sensor according to Claim 10, wherein the working electrode comprises a material selected from the group consisting of gold, carbon, platinum, ruthenium dioxide, palladium, and conductive epoxies.
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12. An electrically non-conductive, nanoparticulate membrane comprising nanoparticles of at least one inorganic oxide of an element selected from Group IA, IIA, IIIA, IVA, IB, IIB, IIIB, IVAB, VB, VIB, VIIB or VIIIB of the Periodic Table, and wherein an oxidoreductase enzyme and an electrochemical activator are diffusibly dispersed in said nanoparticulate membrane.

13. The membrane of claim 12, wherein the electrochemical activator is a polymeric redox mediator capable of transferring electrons.

14. The membrane of claim 12, wherein the element selected from Group IA, IIA, IIIA, IVA, IB, IIB, IIIB, IVAB, VB, VIB, VIIB or VIIIB of the Periodic Table is selected from the group consisting of aluminium, silicon, magnesium and zinc.

15. The membrane of claim 12, wherein the thickness of the membrane ranges from 250 to 500 μm .

16. The membrane of claim 12, wherein the size of the nanoparticles ranges from 10 nm to 1 μm .

17. The membrane of claim 12, wherein the membrane further comprises a polymeric binder.

18. The sensor according to Claim 17, wherein the polymeric binder is a polymer or copolymer comprising monomer units selected from the group consisting of vinyl pyridine, vinyl imidazole, acrylamide, acrylonitrile, and acrylhydrazide and acrylic acid.

19. A process for producing a non-conductive, nanoparticulate membrane, said process comprising

mixing an electrochemical redox mediator with an oxidoreductase and nanoparticles of an inorganic oxide of an element from Group IA, IIA, IIIA, IVA, IB, IIB, IIIB, IVAB, VB, VIB, VIIB or VIIIB of the Periodic Table to form a nanocomposite ink; and
5 applying said nanocomposite ink onto a substrate.

20. The process of claim 19, wherein said nanocomposite ink is applied according to a predetermined pattern.

10 21. The process of claim 20, wherein said nanocomposite ink is applied by screen-printing.

22. The process according to claim 19, wherein the mixing further comprises mixing a polymeric binder into the nanocomposite ink.

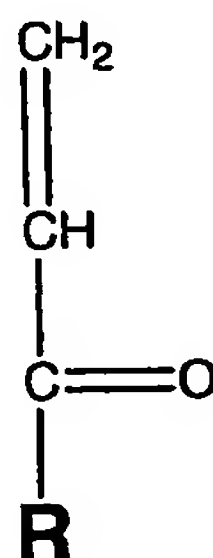
15 23. The process according to claim 19, wherein the concentration of the electrochemical activator in the nanocomposite ink is about 15 mg/ml.

20 24. The process according to claim 19, wherein the concentration of enzyme in the nanocomposite ink is about 0.2 mg/ml.

25. A water soluble redox polymer comprising:
a first monomer unit comprising a polymerisable ferrocene derivative;
and
a second monomer unit comprising an acrylic acid derivative having
25 a primary acid or base functional group capable of acquiring a net charge.

30 26. The redox polymer of claim 25, wherein the second monomer unit comprises an acrylic acid derivative having an terminal primary acid or base functional group capable of acquiring a net charge.

27. The redox polymer of claim 25, wherein the acrylic acid derivative is represented by the general formula (I)



wherein R is selected from the group consisting of $\text{C}_n\text{H}_{2n}\text{-NH}_2$, $\text{C}_n\text{H}_{2n}\text{-COOH}$, $\text{NH-C}_n\text{H}_{2n}\text{-PO}_3\text{H}$ and $\text{NH-C}_n\text{H}_{2n}\text{-SO}_3\text{H}$, wherein the alkyl chain can be optionally substituted, and wherein n is an integer from 0 to 12.

28. The redox polymer of claim 25, wherein the polymerisable ferrocene derivative is selected from the group consisting of vinyl-ferrocene, acetylene-ferrocene, styrene-ferrocene and ethylene oxide-ferrocene.

29. The redox polymer of claim 28, wherein the ferrocene derivative is vinyl ferrocene.

30. The redox polymer of Claim 25, wherein the molecular weight of the redox polymer is between about 1000 and 5000 Daltons.

31. The redox polymer of Claim 25, wherein the ferrocene loading in the redox polymer is between about 3% and 14%.

32. A process for preparing a water soluble, redox polymer, said process comprising:

polymerising a first monomer unit comprising a polymerisable ferrocene derivative with a second monomer unit comprising an acrylic acid derivative having an acid or base functional group capable of acquiring a net charge, wherein said polymerization is carried out in an aqueous alcoholic medium.

33. The process according to Claim 32, wherein the aqueous alcoholic medium comprises ethanol and water in a volumetric ratio of between about 2:1 and 3:1.

34. The process according to Claim 32, wherein the polymerization is initiated by adding a free radical initiator.

35. The process according to Claim 34, wherein the free radical initiator is selected from the group consisting of ammonium persulfate, potassium persulphate and sodium persulfate.

36. The process according to Claim 34 wherein the weight ratio of free radical initiator added is between about 20 mg to 40 mg per 1 gram of monomer.

37. The process according to Claim 32, wherein polymerization is carried out under reflux at a temperature of between about 60 °C to 80 °C.

38. The process according to Claim 33, wherein polymerization is carried out in an inert gas atmosphere.

39. The process according to Claim 32, wherein polymerization is carried out for about 24 hours.

40. The process according to Claim 32, further comprising forming a pre-reaction mixture prior to polymerizing said first and second monomers, comprising:
dissolving the acrylic acid derivative monomer unit in an aqueous alcoholic medium, then
5 adding the free radical initiator, and then
adding the polymerisable ferrocene derivative monomer unit to form the pre-reaction mixture.
- 10 41. The process according to Claim 40, wherein the feeding ratio of acrylic acid derivative to polymerisable ferrocene derivative in the pre-reaction mixture is between about 5 % and 15 % of the weight of monomer added.
- 15 42. The process according to Claim 40, wherein the polymerisable ferrocene derivative monomer unit is dissolved in an aqueous alcoholic medium prior to being added.
- 20 43. The process according to Claim 40, further comprising precipitating the redox mediator in an organic solvent.
44. The process according to Claim 40, wherein the organic solvent is selected from the group consisting of an ether and ketone.
- 25 45. The sensor according to claim 1, wherein the sensor is for determination of glucose concentration.